PAPER

IN

NAVIGATION AND COMMERCE.

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The Thanks of the Society were this Session voted to the Rev. FRANCIS H. EGERTON, of Bridgewater-house, for the following Communication relative to an UNDER-GROUND INCLINED PLANE, executed at Walkden-Moor, in Lancashire, by his Grace the DUKE OF BRIDGEWATER, to whom the GOLD MEDAL was voted, as a testimony of the high opinion entertained by the Society of his Grace's execution of this great work, and his wonderful exertions in Inland Navigation.

I BEG leave to present to the Society an account of the Under-ground inclined Plane, which the Duke of Bridgewater has lately made at Walkden-Moor, between Worsley and Bolton, in Lancashire,

shire. To this account I have subjoined two plans, with a table of reference to each.

At Worsley the Duke of Bridgewater's navigation begins; it goes west to Leigh, and east to Manchester, where it locks up into the Rochdale canal. In its way to Manchester, it turns out, in a western direction, near Longford Bridge, to meet the Grand Trunk Canal, above Preston Brook; and from thence it goes north-west to Runcorn, where it locks down into the Mersey, in the tide-way to Liverpool.

To this navigation above-ground, which, in all its directions, is extended through a length of * forty miles, upon one

* *Forty miles upon one level.*] Adding to these forty miles, nearly twelve miles of the Duke of Bridgewater's Underground Navigable Canal, which lie upon his lower main level, and including eighteen miles of the Grand Trunk Canal betwixt the lowest lock between Middlewich and Preston-Brook, there are seventy miles of navigable canal, without a lock, upon one level, eighty-two feet above low-water mark; whereby a communication is obtained between London, Liverpool, Bristol, and Hull. At this lowest lock the Grand Trunk Navigation locks down, to be upon a level with the Duke of Bridgewater's.

one level, without tunnel or lock, except the locks at the extremities. At Worsley, an under-ground navigation is joined, which goes to the different mines of coal under Walkden-Moor; from which mines, by these navigations above-ground and under-ground, Manchester and various other places are supplied with that valuable article.

The canals of this under-ground navigation lie upon two levels, or stories.

The lower is upon the same level with the open navigation, which it joins at Worsley; and consists, in the different lines which it pursues to the different seams of coal, of near twelve miles of tunnelling.

The higher is thirty-five yards and a half perpendicular height above the level of the lower, and varies from thirty-eight to sixty-one perpendicular yards below the surface of the earth, and consists of near six miles of tunnelling.

The

The tunnelling of each level is ten feet four inches wide, and eight feet six inches deep; and the depth of water, three feet seven inches.

Before a communication was made by an inclined plane, the coals were discharged by hand from the boats on the higher level, and were let down the pits in tubs by an engine and a break-wheel into those upon the lower. To convey the boats themselves from the canals of the higher level into that of the lower, was the intent of making this underground inclined plane. By the help of this machinery, the whole business is now done at once, without discharging or damaging the coal, and at one fourth of the expence: for the boats of the higher level are bodily let down the inclined plane, and are floated from the foot of it through nearly three miles, in a strait line, of the lower level canal, into the open navigation at Worsley: and, whereas they were before obliged

to

to be drawn up to the surface of the earth at great inconvenience and expence, to be repaired at a work-shop on Walkden-Moor, they now come of themselves, in their course of business, to be repaired at the great dock-yard at Worsley.

The place where the inclined plane is constructed, is adapted in a singular way for the purpose. There is a bed of white rock, or grit, eight yards twelve inches deep, which dips one in four, lying exactly in the direction most convenient for the communication between the two levels; which bed of rock is hollowed into a tunnel, driven upon the rise of the metals, by blasting with gunpowder, and working it down with wedges and hammers. In this tunnel, formed through a rock reaching from the lower to the higher level, the inclined plane is fixed; and, by its being in the heart of a rock, the whole workmanship can be pinned, secured, and compacted together

together at the top, bottom, and sides, most effectually :—an advantage which no inclined plane above-ground can have, and which renders this a singular production, no where perhaps to be imitated.

The run of the inclined plane is one hundred and fifty-one yards, besides eighteen yards, the length of the locks, at the north or upper end : and the fall is one in four, corresponding with the dip of the rock.

Of these one hundred and fifty-one yards, about ninety-four yards are formed into a double waggon-way, in order to let two boats, namely, the empty and the loaded boat, pass up and down; and are divided by a brick wall, supporting the roof, in which are openings for a person to escape out of the way of the boats ; which double waggon-way joins in one, about fifty-seven yards from the lower level.

The

The whole width of the double waggon-way is nineteen feet; and of the single waggon-way, after the junction, ten feet.

These waggon-ways are supplied with iron rails, or gullies, laid on sleepers, down the whole run; and the height of the roof, above the iron rails, is eight feet.

At the top of the inclined plane there is a double lock, or rather two locks, side by side, formed in the heart of the same rock, which deliver the loaded boats from the higher level down the inclined plane, and receive the empty boats from the lower. The length of that part of the tunnel in which these are formed, is eighteen yards; the width or diameter, twenty feet six inches; and the height of the roof, at the north end and above the locks, at *d d*, *Plate V. Fig.* 1. twenty-one feet, to admit the break-wheel.

The

The bottom, or south end of the inclined plane, is six feet nine inches under the surface of the water, where the loaded boat floats off the carriage upon the canal of the lower level.

The depth of the locks, under water, at the north end, is four feet six inches; at the south end it is eight feet.

The wall between the locks is nine inches above the surface of the level water; its breadth is three feet.

The diameter of the horizontal main-shaft, upon which the rope works to let the loaded boats down, and to draw the empty boats up, is four feet eleven inches, and its circumference is fifteen feet five inches. The main-rope is two inches and a half in diameter, and seven inches and a half in circumference. It is lapped round with a small cord of about an inch in circumference, for the length of about one hundred and five yards, to prevent its wearing, which it does chiefly when it drags upon the bottom,

tom, when at work, at the place where the waggon-ways unite; and, for the same purpose, rollers of eight inches diameter are fixed at intervals down the run of the inclined plane. Moreover, a hollow cast-iron roller of eight inches and a half diameter is fixed across the west lock, parallel to the upper west lock-gate, and near the north end of the lock, but half a yard higher than the gate, in order to bear up the rope, and to prevent it from swagging.

A hold-fast rope is fastened to the main-rope, to stay each boat upon its waggon, as they go up or down. It is marked *k k*, in *Fig.* 1, *Plate V.* and its uses are more particularly detailed in the table of reference, at *k k*, to that plate.

Upon this horizontal main-shaft is a break-wheel above mentioned, which regulates the motion of the loaded boat going down the inclined plane.

The number of iron teeth, or cogs, in the spur-wheel, which is fastened to the

side of the break-wheel, is three hundred and seventy-two; and the little nut-wheel, *No.* 3, *Fig. II.* which sets it in motion, contains eleven teeth, or cogs. The nut-wheel is supported by two uprights from the pillar to the roof, and works between them. Two winches or handles, *No.* 4 4, *Fig. II.* on its axis, put the main-shaft, *d d*, *Fig. I.* or *No.* 1, *Fig. II.* in motion. The power of both united enables a man, who uses a force equal to forty pounds weight, to set forward two tons upon the waggon-road: and this force, multiplied at the winches or handles, may be used to set forward the loaded boat out of one lock, and to bring the empty boat into the other. The boats being thus put in motion, the little nut-wheel is disengaged from the main-shaft, by a slide drawing the little nut sideways, so as to disengage the teeth, or cogs, from the cogs of the spur-wheel. The weight of four tons going down bring up about one.

The

The spur-wheel, however, which is fastened to the break-wheel, *No.* 2, *Fig. II.* is seldom used, as it is occasionally only put in motion to regulate the stretch of the ropes when new, and to draw the light boat into the lock, when, at any time, it may happen to be over-weighted with materials, such as mortar, props, slabs, &c. for the use of the higher level collieries, and will not move of itself, upon a balance, out of the lower level.

The length of the carriage, or cradle, is thirty feet; its width is seven feet four inches. It moves upon four solid cast-iron rollers, which run upon cast-iron plates; on one side of each of which there are iron crests, which stand two inches higher than the plates, and prevent the carriage from running off the road.

The weight of neat coal, contained in the loaded boat, is about twelve tons: the boat weighs about four tons; and

the carriage, or cradle, in which the boat is placed, when conveyed down the inclined plane, is about five tons:—in all about twenty-one tons.

At this inclined plane thirty loaded boats are now let down, with ease, in about eight hours; that is to say, four boats are let down in a little more than an hour. The boats used in these collieries are of different sizes and dimensions; some will carry seven, some eight and a half, some twelve tons.

The weight of neat coal, independently of the weight of the carriage and boats which is let down the inclined plane, in twelve-ton boats, in eight hours, will consequently be three hundred and sixty tons. The weight of the carriage, suppose five tons, let down in the same time, will be one hundred and fifty tons; and the weight of the boat, suppose four tons, thirty times down, in eight hours, will be one hundred and twenty tons:—in all six hundred and thirty tons down in eight hours.

The

The weight of the carriage thirty times up, and thirty boats up, in eight hours, will be

Carriage, at 5 tons, 30 times up = 150 tons
Boat, at 4 tons, 30 times up = 120 tons

In all 270 tons up in eight hours.

So that there will be 630 tons down
270 tons up

In all 900 tons moved at the inclined plane, in 8 hours, exclusive of an indeterminate quantity of materials occasionally brought up for the use of the higher level collieries.

The various feeders which are loosened by opening the coals in the higher level collieries, as well as three sufficient re-

servoirs, which may occasionally be resorted to, and used in a dry season, keep the higher level always to its height, and afford a constant supply of water to fill the locks, for the purpose of working the inclined plane.

This inclined plane was begun in September, 1795; it was finished, and in use, in October, 1797.

Of this, as of most of his other great works, the Duke of Bridgewater was himself the planner and contriver:—to project greatly, and to execute completely, are the perfection of genius.

The singularity of the place in which it is constructed; the original boldness of the design; the ingenuity and mechanism displayed in planning and executing it; the dispatch with which it has been finished; the simplicity, beauty, and harmony of its parts, tending to one united whole; and, above all, the perfection to which it is proved to have been brought, now that it is practically in use; render

it

it equally astonishing with any other of the stupendous works which have been so ably planned, and so successfully executed, by the first projector and patriotic father of Inland Navigation.

I have the honour to be, &c.

FRANCIS H. EGERTON.

Bridgewater-House,
March 5, 1800.

REFERENCE *to Plate V. being a Plan and Section of his Grace the* DUKE OF BRIDGEWATER'S *Under-ground Inclined Plane, at Walkden-Moor Colliery, near Worsley, in Lancashire.*

Figure 1.

a to *b*, Dip of the metals and waggon-road on the under-ground inclined plane. From *b*, on the lower level, to the mouth of the tunnel, is three miles.

A, The east lock.

B, The west lock.

C, Represents a section of the lock: the dotted line shows the horizontal depth, and the black line under it, the slope upon which the waggon-wheels run to receive the loaded boat, or to bring the empty boat into the lock.

d d, The main-shaft, four feet eleven inches diameter, upon which the ropes work to wind the boats up and down; and here also the break-wheel is fastened on,

on, together with a spur-wheel, and a nut-wheel. See *Fig. II. No.* 1.

e, A passage betwixt the higher level and the locks.

f f, A loaded boat going down, and an empty boat going up the under-ground inclined plane.

G, A brick wall from the sole to the top of the inclined plane, in order to give additional support to the roof.

h h h h, Openings through the brick wall *G*, into which a person may step out of the way of the boats, at the time they are passing up and down.

i, A bell, which is rung by the rope dotted to *b*, upon the lower level, at the bottom of the under-ground inclined plane, to give notice when the empty boat is upon the waggon, or cradle, and when the men below are ready, that the loaded boat may be let down by the men above.

k k, Holdfast-ropes fastened to the main-ropes, and hooked on to a ring at the south end of each boat, as it goes up or down, in order to stay the boats upon the

the waggon or cradle, that they may not swag, or slip off. These holdfast-ropes are spliced on to the end of the main-ropes, and run above and between the two bridle-ropes when they are fastened to the iron uprights, which are upon each side of the waggons, or cradles; and they run over the north end of the boat, to be hooked on to the south end.

l l, The bridle-ropes fastened to the main-ropes at *O*, and secured to two iron uprights upon each side of the waggon, or cradle.

O O, The places where the main-ropes, the bridle-ropes, and the holdfast-ropes, are fastened all together.

No. 1. An open space driven into the side of the lock *A*, to which a pit is sunk from the higher level, in order to convey the water out of the locks down to the lower level, and also to force a current of fresh air into the lower level collieries.

No. 2. A paddle to let the water out of the lock *A*, into the pit *No.* 1.

No.

No. 3. A paddle to let the water out of the lock *B*, through a culvert, represented by dotted lines, under the lock *A*, into the pit *No.* 1.

No. 7, 7. Paddles in the lock-gates, to let the water out of the higher level into the locks.

No. 8, 8. The two north lock-gates, one to each lock, which turn upon the heels of the gates, and swing round when they are opened or shut.

No. 10, 10. Two stops or cloughs, one to each lock, which serve as lock-gates to the south end, and are raised and let down by a windlass.

S, A stop, which is used occasionally when the lock-gates want repairing.

T, The place where the boats which are to pass to or from the lower single waggon-way are directed, at pleasure, into either part of the double waggon-way, by a moveable iron sleeper or plate at that point, upon which sleeper or plate the wheels of the boat-carriage or cradle run.

TABLE *of* REFERENCE *to Plate V. Fig. 2, of his Grace the* DUKE OF BRIDGEWATER'S *Under-ground Inclined Plane, at Walkden-Moor Colliery, near Worsley, in Lancashire.*

1. Main-shaft, on which the rope laps.

2. Break-wheel, on one side of which the spur-wheel is fastened.

3. Nut-wheel, out of geer, but which slides into the spur-wheel, when used to draw the empty boat into the lock occasionally, and which is supported by two uprights from the pillar to the roof.

4, 4. Winches or handles, to work the nut and spur-wheel.

5, 5. The main-ropes fastened to the boats, and which are lapped to prevent their wearing.

6. The spur-wheel, which is fastened on one side of the break-wheel; and on which break-wheel is a strong iron-jointed timber brace, which, according to the pressure

pressure given thereto by the man who attends it, will allow the loaded boat to descend quick or slow, or detain it in its passage.

7, 7. Paddles in the lock-gates, to let the water out of the higher level into the lock.

8. A hollow cast-iron roller, to prevent the main-ropes from swagging.

9. Shroud-wheel, to prevent the ropes going over the end of the main-shaft, slipping off, jerking, or breaking. This stands three inches above the main-shaft.